B 329/987

Preprint from the 1987

BUREAU OF MINES MINERALS YEARBOOK

Bauxite and Alumina

UNITED STATES DEPARTMENT OF THE INTERIOR

The statistical data in this volume represents the most comprehensive, verified, domestic and international coverage for 1987 at the time the volume went to press. More recent information can be found in the quarterly Bauxite Mineral Industry Surveys obtainable from Publications Distribution, Bureau of Mines, Box 18070, Cochrans Mill Road, Pittsburgh, PA 15236.

I 28.37/a:

READEX FICHE best copy available

UNITED STATES DEPARTMENT OF THE INTERIOR • Donald Paul Hodel, Secretary

BUREAU OF MINES • T S Ary, Director

This publication is a chapter from the current Bureau of Mines Minerals Yearbook, comprising *Volume I, Metals and Minerals; Volume II, Area Reports: Domestic; Volume III, Area Reports: International.* The separate volumes of the Yearbook are sold by the Superintendent of Documents, Washington, D.C. 20402.

Bauxite and Alumina

By Luke H. Baumgardner[1] and Ruth A. Hough[2]

World bauxite production increased significantly in 1987 and exceeded 90 million tons[3] for the first time. Mine production was reported from 27 countries. Bauxite production in the United States increased only slightly, although domestic alumina production from imported bauxite rose nearly 34% above 1986 output in response to increased primary aluminum demand. A moderate decrease in the unit value of crude and dried bauxite imports from 1986 to 1987 was reflected in the Bureau of the Census trade data.

Domestic Data Coverage.—Domestic production and consumption data for bauxite and alumina are developed by the Bureau of Mines from five separate voluntary surveys of U.S. operations. Typical of these quarterly and annual surveys is the "Consumption of Alumina" survey. Of the 24 operations canvassed, 23 responded, representing a 96% response rate.

Table 1.—Salient bauxite statistics

(Thousand metric tons and thousand dollars)

	1983	1984	1985	1986	1987
United States:					
Production: Crude ore (dry equivalent)	679	856	674	510	576
Value	$11,309	$15,643	$12,855	r$10,361	$10,871
Exports (as shipped)[1]	74	82	56	69	201
Imports for consumption[1]	7,601	9,435	7,158	6,456	9,156
Consumption (dry equivalent)	9,100	10,519	8,206	6,901	9,548
World: Production	r78,687	r87,799	84,496	p86,093	e90,302

eEstimated. pPreliminary. rRevised.

[1]Excludes calcined bauxite. Includes bauxite imported to the U.S. Virgin Islands.

Legislation and Government Programs.—At yearend, the General Services Administration reported the following deficits in bauxite stockpile goals: 631,000 tons, calcined abrasive grade; 8.679 million tons, Jamaica-type metallurgical grade; 813,000 tons, Suriname-type metallurgical grade; and 1.144 million tons, calcined refractory grade.

DOMESTIC PRODUCTION

Bauxite was produced from surface mining operations in Alabama, Arkansas, and Georgia. Three companies in central Arkansas processed bauxite for diverse end-use markets, a limited amount of which went to primary metal production. At Benton, AR, the Aluminum Co. of America (Alcoa) calcined bauxite for the abrasive and proppant industries and processed crude ore at the company's local Bayer refinery to produce specialty aluminum oxides and hydroxides. Bauxite mined and calcined by the American Cyanamid Co. at Bryant, AR, was shipped to out-of-State plants for production of aluminum sulfate and proppants. Bauxite purchased from a local supplier was used by Porocel Corp. at Berger, AR, to produce activated bauxite chiefly for use in the refining of petroleum. Bauxite from Alabama and Georgia mines, because of its

very low iron oxide content, was used solely for the manufacture of high-alumina refractory products.

Demand for domestic refractory grade ore remained weak during 1987 and mine output was intermittent. In the mining district west of Eufaula, AL, the Harbison-Walker Refractories Div. of Dresser Industries Inc., produced bauxite for the company's local calcining plant and also supplied bauxitic clay to the Carbo Ceramic Co.'s (formerly Standard Oil Proppants Co.) proppant plant at Eufaula. Mullite Co. of America (Mulcoa), an operating unit of C-E Minerals Inc., produced bauxite in Henry County, AL, and Sumter County, GA, for calcining at Mulcoa's plant near Andersonville, GA. The mines and calcining plant of A. P. Green Refractories Co. in the Baker Hill, AL, area were inactive during the year, and the plant and bauxite reserves were sold to C-E Minerals late in the year.

Domestic capacity to produce alumina remained unchanged at 4.57 million tons per year, although Alcoa announced at yearend the planned permanent closing of its Bauxite, AR, mine and 340,000-ton-per-year Bayer alumina plant in October 1988. U.S. alumina production increased substantially compared with 1986 output as it moved in consort with the rise in demand for primary metal. Apparent refinery capacity utilization was about 91%.

Table 2.—Mine production of bauxite and shipments from mines and processing plants to consumers in the United States

(Thousand metric tons and thousand dollars)

Year	Mine production			Shipments from mines and processing plants to consumers[1]		
	Crude	Dry equivalent	Value[2]	As shipped	Dry equivalent	Value[2]
1985	787	674	$12,855	993	989	$34,506
1986	617	510	r10,361	r776	r740	r36,276
1987	689	576	10,871	756	680	22,173

rRevised.
[1]May exclude some bauxite mixed in clay products.
[2]Computed from values assigned by producers and from estimates of the Bureau of Mines.

Table 3.—Recovery of dried, calcined, and activated bauxite in the United States

(Thousand metric tons)

Year	Crude ore treated	Total processed bauxite recovered[1]	
		As recovered	Dry equivalent
1986	250	128	196
1987	131	62	102

[1]Dried, calcined, and activated bauxite. May exclude some bauxite mixed in clay products.

Table 4.—Percent of domestic bauxite shipments, by silica content

SiO_2 (percent)	1983	1984	1985	1986	1987
Less than 8	--	11	74	77	70
From 8 to 15	75	55	14	--	7
More than 15	25	34	12	23	23

Table 5.—Production and shipments of alumina in the United States

(Thousand metric tons)

Year	Calcined alumina	Other alumina[2]	Total[1]	
			As produced or shipped[3]	Calcined equivalent
Production:[e]				
1983	3,540	680	4,220	4,000
1984	4,160	560	4,720	4,545
1985	2,860	860	3,725	3,465
1986	2,570	750	3,320	3,105
1987	3,555	830	4,385	4,150
Shipments:[e]				
1983	3,480	670	4,150	3,945
1984	4,230	570	4,800	4,620
1985	2,890	760	3,650	3,425
1986	2,590	740	3,330	3,120
1987	3,530	845	4,375	4,135

[e]Estimated.
[1]Data may not add to totals shown because of independent rounding.
[2]Trihydrate, activated, tabular, and other aluminas. Excludes calcium and sodium aluminates.
[3]Includes only the end product if one type of alumina was produced and used to make another type of alumina.

Table 6.—Capacities of domestic alumina plants,[1] December 31

(Thousand metric tons per year)

Company and plant	1985	1986	1987
Aluminum Co. of America:			
Bauxite, AR	340	340	340
Point Comfort, TX	1,600	1,735	1,735
Total	1,940	2,075	2,075
Kaiser Aluminum & Chemical Corp.: Gramercy, LA	770	795	795
Reynolds Metals Co.: Corpus Christi, TX	1,700	1,700	1,700
Grand total	4,410	4,570	4,570

[1]Capacity may vary depending upon the bauxite used.

CONSUMPTION AND USES

Bauxite consumption rose in 1987 compared with that of 1986, with significant gains in calcined refractory grades and crude and dried metallurgical grades. Domestic producers benefited little as the increase was supplied largely from imports. Consumption by the chemical industries was unchanged, while calcined abrasive grade bauxite, including feedstocks to the proppants industries, continued a declining trend begun in 1985. Low world oil prices removed the incentives for petroleum producers to use proppants. About 90% of the bauxite consumed in the United States was refined to alumina and an estimated average of 2.07 tons of dried bauxite was required to produce 1 ton of calcined alumina. Twenty-one primary aluminum smelters consumed 7.5 million tons of calcined alumina. An estimated 84% of alumina shipped by U.S. refineries went to domestic primary smelters. Consumption by abrasives, chemicals, refractories, and other industries accounted for the balance of the alumina in calcined, hydroxide, activated, tabular, and other forms.

Table 7.—U.S. consumption of bauxite, by industry

(Thousand metric tons, dry equivalent)

Industry	Domestic	Foreign	Total
1986:			
Alumina	[1]460	[1]5,779	5,980
Abrasive[2]	W	W	259
Chemical	[2]37	[2]253	231
Refractory	80	292	372
Other	W	W	59
Total[1 3]	577	6,324	6,901
1987:			
Alumina	[1]490	[1]8,335	8,601
Abrasive[2]	W	W	224
Chemical	[2]34	[2]267	243
Refractory	68	354	422
Other	W	W	58
Total[1 3]	592	8,956	9,548

W Withheld to avoid disclosing company proprietary data; included with "Other" or "Total."
[1]Includes "Abrasive."
[2]Includes consumption by Canadian abrasive industry.
[3]Includes "Other."

Table 8.—U.S. consumption of crude and processed bauxite

(Thousand metric tons, dry equivalent)

Type	Domestic origin	Foreign origin	Total
1986:			
Crude and dried	W	W	6,305
Calcined and activated	W	W	597
Total	577	6,324	[1]6,901
1987:			
Crude and dried	W	W	8,924
Calcined and activated	W	W	624
Total	592	8,956	9,548

W Withheld to avoid disclosing company proprietary data; included in "Total."
[1]Data do not add to total shown because of independent rounding.

Table 9.—Production and shipments of selected aluminum salts in the United States in 1986

Item	Number of producing plants	Production (thousand metric tons)	Total shipments including interplant transfers	
			Quantity (thousand metric tons)	Value (thousands)
Aluminum sulfate:				
Commercial and municipal (17% Al_2O_3)	82	1,109	1,060	$129,361
Iron-free (17% Al_2O_3)	26	109	103	13,872
Aluminum chloride:				
Liquid and crystal	3	5	W	W
Anhydrous (100% $AlCl_3$)	4	W	W	W
Aluminum fluoride, technical	3	W	W	W
Aluminum hydroxide, trihydrate (100% $Al_2O_3 \cdot 3H_2O$)	7	479	540	126,639
Other aluminum compounds[1]	NA	NA	NA	61,013

NA Not available. W Withheld to avoid disclosing company proprietary data.
[1]Includes sodium aluminate, light aluminum hydroxide, cryolite, and alums.

Source: Data are based upon Bureau of the Census 1986 Current Industrial Reports, Series MA-28A, "Inorganic Chemicals."

Table 10.—Stocks of bauxite in the United States,[1] December 31

(Thousand metric tons, dry equivalent)

Sector	1986[r]	1987
Producers and processors	186	212
Consumers	3,133	2,824
Government	18,472	18,472
Total	21,791	21,508

[r]Revised.
[1]Domestic and foreign bauxite; crude, dried, calcined, activated; all grades.

Table 11.—Stocks of alumina in the United States,[1] December 31

(Thousand metric tons, calcined equivalent)

Sector	1986[r]	1987
Producers[e]	148	141
Primary aluminum plants	1,888	2,685
Total[e]	2,036	2,826

[e]Estimated. [r]Revised.
[1]Excludes consumers' stocks other than those at primary aluminum plants.

PRICES

Contract terms for the purchase of metal grade bauxite and cell grade alumina in world markets are not normally made public, and consequently, prices for these commodities are not published by trade journals. Price quotes are generally limited to certain specialty forms of bauxite and alumina for nonmetallurgical uses.

In 1987, the Bureau of Mines estimated the average value of domestic crude bauxite shipments, f.o.b. mine or plant, to be $15.79 per ton. The average value of calcined domestic bauxite was estimated to be $128 per ton. Quoted base prices for imported calcined refractory grade bauxite were: Chinese, typical 85% Al_2O_3, f.o.b. barge, Burnside, LA, $95 to $120 per ton; Guyanese, minimum 86% Al_2O_3, f.o.b. railcar, Baltimore, MD, or f.o.b. barge, Burnside, LA, or Mobile, AL, $164.76 per ton. These base prices were subject to adjustment for grain-size specifications, size of order, and fuel cost factors.

The average value of domestic calcined alumina shipments was estimated to be $143 per ton. The average value of imported calcined alumina indicated by trade data of the Bureau of the Census was $141 per ton, f.a.s. port of shipment, and $152 per ton, c.i.f. U.S. ports.

Table 12.—Average value of U.S. imports of crude and dried bauxite[1]

(Per metric ton)

Country	1986		1987	
	Port of shipment (f.a.s.)	Delivered to U.S. ports (c.i.f.)	Port of shipment (f.a.s.)	Delivered to U.S. ports (c.i.f.)
To U.S. mainland:				
Australia	$15.43	$23.43	$13.96	$22.45
Brazil	24.58	27.53	24.14	29.24
Guinea	25.98	32.73	19.66	26.88
Guyana	34.02	45.45	31.89	44.20
Jamaica	30.93	34.99	30.54	34.24
Suriname	37.36	47.35	23.77	32.22
Weighted average	27.54	33.66	23.32	29.48

[1]Computed from quantity and value data reported to U.S. Customs Service and compiled by the Bureau of the Census, U.S. Department of Commerce. Not adjusted for moisture content of bauxite or differences in methods used by importers to determine value of individual shipments.

Table 13.—Market quotations on alumina and aluminum compounds

(Per metric ton, in bags, carlots, freight equalized)

Compound	Dec. 30, 1986	Dec. 31, 1987
Alumina, calcined	$418.88	$418.88
Alumina, hydrated, bulk	209.44	209.44
Alumina, activated, granular, works	905.00	905.00
Aluminum sulfate, commercial, ground (17% Al_2O_3)	225.97	225.97
Aluminum sulfate, iron-free, dry (17% Al_2O_3)	330.69	330.69

Source: Chemical Marketing Reporter.

FOREIGN TRADE

Exports of dried bauxite totaled 146,000 tons in 1987, nearly quadruple the quantity exported in 1986. Venezuela received 101,000 tons, Canada, 38,000 tons, and Suriname, 7,000 tons. Of the total 55,000 tons of calcined bauxite exported, Mexico received 52,000 tons and Canada, 3,000 tons.

Ghana became a major destination of U.S. alumina exports because of the closure of the Alpart refinery in Jamaica, its usual source. Alumina exports to Canada, Ghana, and Mexico were more than double the quantities shipped in 1986 and accounted for 88% of the 1987 exports.

Imports for consumption of crude and dried bauxite increased significantly over 1986 receipts, and the three traditional principal suppliers, Australia, Guinea, and Jamaica provided 90% of the total.

Ghana became a new supplier of metal grade bauxite to the United States. Imports from all source countries increased compared with those of 1986, with the exception of those from Suriname, where guerrilla action by insurgents shut down that country's largest bauxite mine for most of the year.

Australia continued to be the dominant source of U.S. alumina imports for consumption (83% of the total), and imports from all sources except Jamaica increased with respect to 1986 receipts.

Table 14.—U.S. exports of alumina,[1] by country

(Thousand metric tons, calcined equivalent, and thousand dollars)

Country	1985		1986		1987	
	Quantity	Value	Quantity	Value	Quantity	Value
Argentina	[2]	$178	1	$624	1	$629
Belgium-Luxembourg	2	2,209	2	3,485	2	2,543
Brazil	1	770	--	593	75	10,789
Canada	126	30,561	263	47,491	575	89,890
France	[2]	747	--	1,259	1	2,005
Germany, Federal Republic of	3	4,958	3	4,379	1	2,989
Ghana	--	--	77	12,540	270	38,942
Japan	1	2,443	21	6,426	24	8,162
Mexico	104	28,451	91	23,627	150	32,431
Netherlands	1	[r]2,476	1	2,365	2	2,274
Norway	45	7,417	11	645	[2]	13
Sweden	22	2,546	--	456	[2]	106
United Kingdom	3	4,803	2	2,441	2	2,134
Venezuela	1	1,138	1	1,573	2	1,512
Other	6	11,133	14	17,416	22	13,617
Total[3]	316	99,829	487	125,322	1,127	208,037

[r]Revised.

[1]Includes exports of aluminum hydroxide (calcined equivalent) as follows: 1985—16,700 tons; 1986—12,199 tons; and 1987—18,727 tons.

[2]Less than 1/2 unit.

[3]Data may not add to totals shown because of independent rounding.

Source: Bureau of the Census.

Table 15.—U.S. imports for consumption of bauxite, crude and dried,[1] by country

(Thousand metric tons)

Country	1985	1986	1987
Australia	829	879	1,167
Brazil	560	100	451
China	9	21	5
Dominican Republic[2]	6	1	70
Ghana	--	--	39
Guinea	3,752	3,356	4,256
Guyana	225	169	244
Jamaica[2]	1,540	2,119	2,799
Sierra Leone	56	--	--
Suriname	176	112	104
Other	r5	(3)	24
Total[4]	7,158	6,456	9,158

rRevised.
[1]Includes bauxite imported to the U.S. Virgin Islands from foreign countries.
[2]Dry equivalent of shipments to the United States.
[3]Revised to zero.
[4]Data may not add to totals shown because of independent rounding.

Note.—Total U.S. imports of crude and dried bauxite (including the U.S. Virgin Islands) as reported by the Bureau of the Census were as follows: 1985—7,257,840 tons; 1986—6,854,083 tons; and 1987—9,827,818 tons.

Source: Bureau of the Census and the Jamaican Bauxite Institute.

Table 16.—U.S. imports for consumption of calcined bauxite, by country

(Thousand metric tons and thousand dollars)

Country	1986				1987			
	Refractory grade		Other grade		Refractory grade		Other grade	
	Quantity	Value[1]	Quantity	Value[1]	Quantity	Value[1]	Quantity	Value[1]
Australia	--	--	14	$1,110	--	--	6	$416
China	112	$8,958	48	3,881	163	$10,708	10	714
Guyana	109	14,232	9	935	107	14,995	22	1,230
Suriname	--	--	11	558	--	--	4	160
Other	--	--	(2)	41	--	--	(2)	26
Total[3]	221	23,190	83	6,526	270	25,703	43	2,545

[1]Value at foreign port of shipment as reported to U.S. Customs Service.
[2]Less than 1/2 unit.
[3]Data may not add to totals shown because of independent rounding.

Source: Bureau of the Census.

Table 17.—U.S. imports for consumption of alumina,[1] by country

(Thousand metric tons, calcined equivalent, and thousand dollars)

Country	1985		1986		1987	
	Quantity	Value[2]	Quantity	Value[2]	Quantity	Value[2]
Australia	3,014	$564,212	3,051	$458,965	3,361	$431,041
Brazil	48	9,280	20	4,720	25	4,977
Canada	42	16,958	42	16,109	59	25,078
France	5	11,046	5	12,019	7	13,825
Germany, Federal Republic of	11	13,898	13	14,924	14	20,922
Jamaica	372	66,171	140	20,870	90	13,107
Japan	4	4,112	3	3,371	6	6,688
Suriname	326	42,949	r268	r30,465	324	40,568
Venezuela	--	--	55	9,712	111	13,986
Other	5	6,614	r6	r8,555	71	11,719
Total	3,827	735,238	3,603	574,210	4,068	r581,864

rRevised.
[1]Includes imports of aluminum hydroxide.
[2]Value at foreign port of shipment as reported to U.S. Customs Service.
[3]Data do not add to total shown because of independent rounding.

Source: Bureau of the Census.

WORLD REVIEW

Bauxite mines and alumina plants raised production levels during the last quarter of 1987 to meet the rising demand for alumina to make primary aluminum metal. Venezuela joined the ranks of world bauxite producers with the opening of mining operations in the State of Bolívar, and the Dominican Republic reopened bauxite mines that had been shut down in 1982. China reported the discovery of a large bauxite deposit. The Governments of Guinea, Jamaica, and Suriname were reported to have reached tentative agreements with the bauxite-producing companies to revise or rescind bauxite production levies.

Australia.—The world's largest bauxite- and alumina-producing country set new production records for the fifth consecutive year. Comalco Ltd. reported bauxite production and shipments of 8.02 and 7.81 million tons, respectively, from its mining complex at Weipa, Queensland. In addition to the production of metal grade bauxite, in other operations at Weipa the company calcined bauxite for use in abrasives and proppants and mined and processed kaolin clay from deposits underlying the bauxite ore. Queensland Alumina Ltd., at Gladstone, Queensland, owned by Comalco (30.3%), Kaiser Aluminum and Chemical Corp. (28.3%), Alcan Australia Ltd. (21.4%), and Pechiney Corp. (20%) produced about 2.77 million tons of alumina.

At Gove, in the Northern Territory, the alumina plant owned by Swiss Aluminium Australia Ltd. (Austraswiss) (70%) and Gove Alumina Ltd. (30%), also operated at full capacity with production close to 1.4 million tons. Bauxite exports declined as Japan continued to shut down alumina plants. In July, Austraswiss announced that it had successfully resolved the 1986 dispute in which the Australian Government claimed that the company was underpricing its alumina sales to gain tax benefits.

In Western Australia, Alcoa of Australia Ltd. operated the Kwinana, Pinjarra, and Wagerup alumina plants at capacity, as did the Worsley Alumina Pty. Ltd., owned jointly by Reynolds Alumina Australia Ltd. (40%), Shell Co. of Australia Ltd. (30%), The Broken Hill Pty. Co. Ltd. (BHP) (20%), and Kobe Alumina Associates (Australia) Pty. Ltd. (10%). Western Australia's bauxite and alumina operations were overshadowed by news reports on the development of gold deposits associated with the bauxite in the Boddington area. The Worsley group poured the first commercial gold at its Boddington mine and plant in August, and Alcoa of Australia sought mining rights to the gold reserves on its bauxite lands adjoining the Boddington deposits. BHP announced that it intended to sell its share of Worsley Alumina to Hydro Aluminium A/S, a subsidiary of Norsk Hydro A/S, Norway.

Brazil.—Sales of bauxite by Mineração Rio do Norte S.A. (MRN) from its mining operations at Trombetas reached a record high of 5.3 million tons. Participants in the consortium included state-owned Companhia Vale do Rio Doce (CVRD) holding a 46% interest, Alcan Alumínio do Brasil S.A. (24%), Companhia Brasiliera de Aluminio (10%), Billiton Metais S.A. (10%), Norsk Hydro (5%), and Reynolds Aluminio S.A. (5%). The bauxite sales-price dispute that began in 1986 continued through 1987 as the private commercial partner-customers argued against CVRD's move to increase the price. The $25.68 per ton price at the beginning of the year was raised to $28.50 on April 1, and then reduced to provisional prices of $26.97 in August and $26.68 in October. Most of the bauxite exported by MRN was shipped to Canada, the United States, and Venezuela.

The proposed Aluminio do Norte do Brasil S.A. alumina plant to be built on the Amazon River near Belém by CVRD (60%), and the Japanese consortium, Nippon Amazon Aluminium Co. (NAAC), was stalled in the early construction stages by NAAC's decision at yearend 1986 not to provide additional capital to cover its 40% interest in the 800,000-ton-per-year plant. The refinery was sited next to the newly completed ALBRAS aluminum smelter, owned jointly by CVRD and NAAC, and was designed to supply the smelter's alumina requirements. A drought-related electrical power shortage during 1987 forced cutbacks in smelter production at Alcan's Aratu plant and at the Alumínio do Maranhão plant owned by Alcoa Alumínio S.A. (60%) and Billiton Metais (40%), thus reducing bauxite and alumina consumption at these facilities.

China.—The discovery of a 500-million-ton bauxite deposit in Shanxi Province was reported by the Ministry of Geology and Mineral Resources. The verified ore reserves were stated to be of high grade and to

be near the surface, and the deposit was estimated to contain more than 40% of the known bauxite reserves in China. A primary aluminum complex is planned at Yumenkou, on the Yellow River in the southwest region of Shanxi Province. The first stage, a 200,000-ton-per-year alumina plant, was nearing completion after more than 3 years of construction and was expected to be in production late in 1987. A coal-fired powerplant and a limestone mine were also to be completed in the first stage, the latter to supply lime for the combination Bayer/lime-soda-sinter process. Second and third stages were expected to increase progressively annual alumina capacity to 2 million tons and complete a 300,000-ton-per-year aluminum smelter by the year 2000. China has been a net importer of aluminum, but development of the aluminum industry has been given high priority in anticipation of rapid growth in domestic consumption.

India.—The largest bauxite mine in Asia was opened by the National Aluminium Co. Ltd. (NALCO) in February at Panchpatmali in Orissa State. Bauxite reserves were reported to be 317 million tons and the annual capacity of the mining operation was about 2.4 million tons. The mine was part of a complex that included a 600-megawatt power facility, a 218,000-ton-per-year primary aluminum smelter, and an 800,000-ton-per-year alumina plant at Damanjodi. Pechiney of France provided the design technology. Contracts were signed by NALCO to sell 50,000 tons of alumina to Poland and 100,000 tons of alumina to Norsk Hydro ASV. Initial shipments to each were to commence in 1987.

Jamaica.—In 1987, Jamaica was the second largest supplier of metal grade bauxite and fourth largest supplier of alumina to the United States. Although four of the world's largest aluminum companies have bauxite mining and refining operations on the island, fuel costs, bauxite production levies, and a depressed aluminum market from 1984 through early 1987 combined to hold production levels down and reduce revenue to the Government. Increased bauxite exports to the United States and the U.S.S.R. were insufficient to offset the continued low exports of alumina. The Jamaican Government continued production at Alcoa's Clarendon alumina plant under a 2-year lease signed in mid-1985 and sold the alumina through Clarendon Ltd., a Swiss trading company. Jamaica's efforts to purchase the plant were unsuccessful and in October, Alcoa announced that it would resume full control of the plant when the lease contract expired in February 1988. Alcan was urged by the Government to restart idled capacity at the Ewarton refinery, and Kaiser and Reynolds were pressured to reopen the Alpart refinery. Negotiations between Jamaica and the companies were in progress at yearend, and they had reached a tentative agreement that bauxite levies would be adjusted downward in exchange for increased alumina production.

Suriname.—Bauxite and alumina production problems continued throughout the year for the Suriname Aluminum Co. (Suralco), the wholly owned Alcoa subsidiary. The Moengo bauxite mine was closed by insurgent rebel action in November 1986, and remained shut down for most of 1987. Emergency arrangements were made to import bauxite ore to supply the 1.4-million-ton-per-year Paranam alumina plant owned by Suralco (55%) and Billiton International Metals BV (45%), but the plant was forced to close in February 1987 when equipment was damaged by idled workers. Suralco's aluminum smelter was closed in January after antigovernment rebels blew up the powerlines to the plant. Although the power supply was repaired, the smelter could not be restarted in 1987 owing to low water levels at the hydroelectric plant.

Venezuela.—After 20 years of importing raw materials for the production of primary aluminum, Venezuela became a fully integrated metal producer with the opening in June 1987 of Los Pijiguaos bauxite mine on the Orinoco River. Beginning in September, 134,000 tons of ore was barged 650 kilometers down the Orinoco to the Interamericana de Alúmina C.A. (INTERALUMINA) plant at Puerto Ordaz, where the bauxite was refined to alumina to supply the two adjacent primary metal smelters. C.V.G. Bauxita Venezolana C.A., the state-controlled operating company in which Alusuisse holds a 3.5% interest, planned to raise the mine capacity to 3 million tons per year in 1988. Capacity increases for INTERALUMINA and both smelters were also scheduled for 1988-89. The Government was seeking joint-venture participation with the world's major aluminum producers and fabricators. The availability of low-cost hydroelectric power should prove a strong incentive to new industry.

Table 18.—Bauxite: World production, by country[1]

(Thousand metric tons)

Country	1983	1984	1985	1986[p]	1987[e]
Australia	24,372	31,537	31,889	32,384	34,000
Brazil	7,199	6,433	5,846	6,544	7,250
China[e]	1,600	1,600	1,650	1,650	2,400
Dominican Republic[2]	--	--	--	--	[3]211
France	1,663	1,607	1,530	1,379	[3]1,271
Germany, Federal Republic of	([4])	([4])	([4])	([4])	([4])
Ghana	70	[r]44	170	226	[3]230
Greece	2,455	2,296	2,453	2,230	2,400
Guinea[5]	12,421	13,160	13,100	12,130	13,400
Guyana[2]	1,087	1,333	[e]1,675	1,466	2,200
Hungary	2,917	2,994	2,815	3,022	[3]3,101
India	[r]1,976	[r]2,093	2,281	2,322	[3]2,685
Indonesia	778	1,003	830	650	[3]635
Italy	13	--	--	--	--
Jamaica[e 6]	7,683	8,937	5,975	6,944	[3]7,775
Malaysia	502	680	492	559	[3]482
Mozambique	--	--	5	4	5
Pakistan	3	3	2	3	4
Romania[e]	650	620	600	600	600
Sierra Leone	785	1,040	1,184	1,242	[3]1,390
Spain	5	7	2	[e]7	4
Suriname	3,400	3,454	[e]3,000	3,847	1,200
Turkey	306	132	214	291	[3]247
U.S.S.R.[e 7]	4,600	4,600	4,600	4,600	4,600
United States[2]	679	856	674	510	[3]576
Venezuela[8]	--	--	--	--	[3]217
Yugoslavia	3,500	3,347	3,538	3,459	[3]3,394
Zimbabwe	23	23	21	24	25
Total	[r]78,687	[r]87,799	84,496	86,093	90,302

[e]Estimated. [p]Preliminary. [r]Revised.

[1]Table includes data available through July 8, 1988.

[2]Dry bauxite equivalent of crude ore.

[3]Reported figure.

[4]Less than 1/2 unit.

[5]Dry bauxite equivalent of ore processed by drying plant.

[6]Bauxite processed for conversion to alumina in Jamaica plus kiln-dried ore prepared for export.

[7]In addition to the bauxite reported in the body of the table, the U.S.S.R. produces nepheline syenite concentrates and alunite ore as sources of aluminum. Estimated nepheline syenite concentrate production was as follows, in thousand metric tons: 1983—2,500; 1984—2,500; 1985—2,500; 1986—2,500; and 1987—2,500. Estimated alunite ore production was as follows, in thousand metric tons: 1983—615; 1984—615; 1985—615; 1986—620; and 1987—625. Nepheline syenite concentrate grades 25% to 30% alumina, and alunite ore grades 16% to 18% alumina; these commodities may be converted to their bauxite equivalent by using factors of 1 ton of nepheline syenite concentrate equals 0.55 ton of bauxite and 1 ton of alunite equals 0.34 ton of bauxite.

[8]The new Los Pijiguaos Mine came on-stream in mid-1987.

Table 19.—Alumina: World production,[1] by country[2]

(Thousand metric tons)

Country	1983	1984	1985	1986[p]	1987[e]
Australia	7,231	8,781	8,792	9,423	[3]10,105
Brazil	787	891	1,096	1,258	1,200
Canada	1,116	1,126	1,019	[e]1,100	[3]953
China[e]	800	800	825	825	1,200
Czechoslovakia	80	85	[e]85	[e]85	85
France	853	898	734	740	[3]711
German Democratic Republic	42	43	47	46	46
Germany, Federal Republic of[4]	[r]1,346	[r]1,417	1,368	1,250	[3]1,017
Greece	410	482	360	470	480
Guinea	[r]573	[r]538	572	556	543
Hungary	836	811	798	856	[3]858
India	[e]450	588	587	[e]600	700
Ireland	66	653	555	686	[3]784
Italy	466	607	555	618	585
Jamaica	1,851	1,749	1,513	1,575	1,610
Japan	1,065	1,172	978	607	[3]358
Romania	512	552	548	555	550
Spain	737	742	725	[e]725	812
Suriname	1,129	1,208	[e]1,000	1,471	[3]1,370
Turkey	57	75	113	144	[3]95

See footnotes at end of table.

Table 19.—Alumina: World production,[1] by country[2] —Continued

(Thousand metric tons)

Country	1983	1984	1985	1986[p]	1987[e]
U.S.S.R.[e]	3,200	3,300	3,500	3,700	3,700
United Kingdom	93	105	110	[r]110	110
United States[3]	4,000	4,545	3,465	[r]3,105	4,150
Venezuela	560	1,139	[4]1,085	[r 4]1,300	[4]1,381
Yugoslavia	1,010	1,135	1,138	1,130	1,135
Total	[r]29,270	[r]33,442	31,588	[5]32,936	[5]34,539

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Figures presented generally represent calcined alumina; exceptions are noted individually.
[2]Table includes data available through July 8, 1988.
[3]Reported figure.
[4]Series revised to reflect calcined alumina; previously shown as hydrate output.
[5]Data do not add to total shown because of independent rounding.

Table 20.—World annual alumina capacity, by country

(Thousand metric tons, yearend)

Country	1985	1986	1987
Australia	9,750	9,750	10,000
Brazil	1,150	1,150	1,150
Canada	1,225	1,225	1,225
China	850	850	1,300
Czechoslovakia	100	100	100
France	1,040	1,040	1,040
German Democratic Republic	65	65	60
Germany, Federal Republic of	1,745	1,745	1,745
Greece	500	500	500
Guinea	700	700	700
Guyana	355	355	355
Hungary	895	920	920
India	675	675	1,000
Ireland	800	800	800
Italy	920	920	720
Jamaica	2,825	2,825	3,100
Japan	1,060	975	550
Romania	540	540	540
Spain	800	800	800
Suriname	1,350	1,350	1,350
Turkey	200	200	200
U.S.S.R.	4,500	4,600	4,600
United Kingdom	140	120	120
United States	4,410	4,570	4,570
Venezuela	1,000	1,000	1,300
Yugoslavia	1,635	1,635	1,635
Total	39,230	39,410	40,380

TECHNOLOGY

The Bureau of Mines described research on the recovery of alumina from domestic alunite ($KAl_3(SO_4)_2(OH)_6$) deposits.[4] In the initial step of the process, the alunite was sulfated by treating it with hot, concentrated sulfuric acid. Hot water was used to leach out the acid-insoluble aluminum sulfate that was precipitated out as crystals, as the solution cooled. By calcining the aluminum sulfate crystals, cell-grade alumina could be produced. The potassium compounds that accumulated in the sulfuric acid were retained for subsequent recovery.

A number of advanced ceramics, including aluminum oxide (alumina), have recently been developed for surgical implants. These new "bioceramics" were reviewed in January 1987.[5] Alumina powder, with a purity ranging from 99.5% to 99.9%, is compressed isostatically and fired at 1,500° C to 1,700° C to produce a hard, inert ceramic of high density. The monocrystalline form is similar to single-crystal sapphire with a hardness of nine on Mohs scale. A polycrystalline form of alumina ceramic, though not as dense or as hard as the single crystal form, is better suited to some implant applications. For tooth im-

plants, the transparent monocrystalline alumina is preferred for the root section inserted into the jaw bones. The softer white polycrystalline alumina, which can be more readily shaped and contoured to match the natural teeth, works well as the exposed crown section. The extreme hardness, resistance to wear and chemical attack, and low coefficient of friction make monocrystalline alumina an excellent material for the ball and socket of artificial hip and knee joints.

Awareness of the limited domestic bauxite resources has led to extensive research programs for more than 40 years by industry and the Bureau of Mines to develop alternate sources of aluminum oxide for the production of primary aluminum. The presence of extensive clay resources has made these aluminum silicates a prime target of research, and the more recent work has centered on various processes for recovering the aluminum as a trichloride compound. The Toth Aluminum Corp. has reported commercial production of high purity $AlCl_3$ from Georgia kaolin at its Vacherie, LA, plant. The details of the carbochlorination process employed in the 5,000-ton-per-year plant were described.[6] The company was initially selling an aluminum chloride product rather than the proposed aluminum oxide. However, discussions have been reported between Toth and Alcoa regarding the possible sale to Toth of Alcoa's now-closed experimental smelter at Palestine, TX, designed to produce primary aluminum by direct reduction of aluminum chloride feed using the Alcoa Smelting Process.

Among the relatively low-cost mineral fillers used in plastics, rubber, wire insulation, and synthetic marble and onyx, alumina trihydrate (ATH) is unique in that it is compatible with most polymers, has a bright white color, and acts as a flame retardant and smoke suppressant. In the specialty alumina markets, growth in demand for ATH as a filler was second only to that of alumina in ceramics.[7] For the production of polyester-based synthetic onyx, Na_2O content, color, particle size, and particle size distribution of the ATH are all critical elements. The quality of the synthetic onyx can be improved in brightness, translucency, and color if the ratio of ground to unground ATH crystals and the specific surface area of the particles are closely controlled.

At the MRN-operated Trombetas bauxite mine on the Amazon River, Brazil, washing operations generate an annual tailings volume of about 18 million cubic meters with a solids content of 7% to 9%.[8] Mine capacity is 5 million tons per year of beneficiated bauxite after approximately 1.7 million tons of -400 mesh solids are removed in the washing plant. The handling and disposal of such a large volume of material required careful testing and planning. The plan selected used an intermediate settling pond where the tailings were allowed to thicken before being recovered by a dredge and pumped to the final impoundment cells in the mined-out areas. The cells were to be filled in two stages and after settling for 2 years, topsoil was to be spread and new vegetation started.

---

[1]Physical scientist, Branch of Nonferrous Metals.

[2]Supervisory mineral data assistant, Branch of Nonferrous Metals.

[3]All quantities in this chapter are given in metric tons unless otherwise specified.

[4]Wouden, M. L., L. J. Froisland, and M. B. Shirts. Recovery of Alumina From Alunite by Acid Sulfation. Metall. Soc. AIME Tech. Paper A87-22, 1987, 10 pp.

[5]Boretos, J. W. Advances in Bioceramics. Adv. Ceram. Mater., v. 2, No. 1, Jan. 1987, pp. 15-22.

[6]McCallion, J. Carbo-chlorination of Georgia Clay Yields High Purity $AlCl_3$. Chem. Process., v. 50, No. 2, Feb. 1987, pp. 53-54.

[7]Sato, C., S. Kazama, and Y. Oda. New Developments in Alumina Trihydrate for Flame Retardant Filler. Paper in Light Metals 1987, ed. by R. D. Zabreznik. Metall. Soc. AIME, Denver, CO, 1987, pp. 99-104.

[8]Lapa, R. P., and W. Cardoso. Tailings Disposal at the Trombetas Bauxite Mine. Paper in Light Metals 1988, ed. by L. G. Boxall. Metall. Soc. AIME, Phoenix, AZ, 1988, pp. 65-76.

☆ U.S. GOVERNMENT PRINTING OFFICE: 1988— 242-377/80062